COASTAL TREE FERN COMMUNITIES AT WESTERN PORT, VICTORIA

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Abstract: An occurrence of the rough tree fern, *Cyathea australis*, on coastal bluffs near Point Leo, Western Port, is described. The presence of this species, normally found as an understorey component in cool, humid forests in Victoria, is unusual. It is concluded that the establishment and survival of *Cyathea australis* in a coastal environment is dependent upon the existence of suitable micro-habitats, offering sufficient soil moisture and protection from salt laden S and SE winds. Such micro-habitats are created by small-scale rotational slumping, which occurs frequently in the study area. The slumping is in turn related to a probable rise in water table levels, exacerbated by extensive clearing of native forest in the immediate hinterland.

Tree ferns are characteristic of cool humid gullies in Victoria, so it is surprising to find them on coastal bluffs within 50 m of the high tide mark. The rough tree fern, *Cyathea australis*, occurs on basalt bluffs at Shoreham, Coles' Beach, Merricks and Somers (Figs 1 & 2) on Western Port. An isolated occurrence is found at the base of cliffs composed of lateritized Tertiary clays at Freeman's Point on the NE coast of French Island. In all coastal sites it is confined to wet or unstable soils.

The tree fern sites at Somers and Shoreham are at present being overwhelmed by blackberry thickets 2 to 3 m deep. At the main Coles' Beach study site, blackberries had increased upslope alarmingly between 1974 and 1977, from well entrenched colonies at the bluff-dune junction. The need to describe this unusual plant community was therefore urgent and such a project was initiated in June 1977 by a group of second year ecology students—Fiona Ferwerda, Jane Mallen, Wayne Antrobus and Jan Brown.

DISTRIBUTION OF *Cyathea australis*

This tree fern ranges from Queensland to the NW tip of Tasmania. In Victoria its distribution is generally restricted to areas receiving an annual rainfall of over 750 mm. It is therefore most commonly found in hilly highland regions up to altitudes of approximately 900 m (Fig. 3). Where annual rainfall exceeds 1000 mm, it is found as an understorey component in forests on valley sides or even on ridge tops. In areas of lower rainfall, however, it is confined to sheltered, moist habitats. An interesting example of this in the Creswick area is its occurrence along the moist sides of shallow mine shafts abandoned since the late 1800's (R. Hately pers. comm. 1980).

The occurrence of *C. australis* along the coastal slopes of Western Port lies close to its general annual rainfall limit in Victoria, and as a consequence it is found only on the cooler east to south aspects and where there is moderate protection from salty onshore winds (Fig. 4a, b). It is absent from the taller bluffs on the Bass Strait coast at Flinders, where there are similar aspects, rainfall and microtopography, but where there are probably rougher seas and stronger and more salt-laden S and SE winds. The tree fern communities at Shoreham and Somers are protected by the canopies of *Eucalyptus* and *Banksia* forests and woodlands, or by thickets of coast tea-tree (*Leptospermum laevigatum*) nearer the shore.

At Western Port, *Dicksonia antarctica* is rare, and single specimens only have been found in two localities at Coles' Beach. One occurs in the incised course of Short Creek and the other, although salt burnt, grew in a seepage area of *Melaleuca ericifolia*, 10 m from the beach sand. In 1976 it was cut down and removed, presumably by a gardener.

ENVIRONMENT OF THE WESTERN PORT SITES

Climate

The climate of the Western Port coastal region is typically temperate and maritime. The well distributed annual rainfall ranges from 750-900 mm and is relatively reliable (Fig. 5a, b). Frosts are neither common nor severe. Very wet years (1 standard deviation above the mean) have occurred this century nine times.

Geology and Soils

Accounts of the geology of the Mornington Peninsula and Western Port region by numerous authors were summarized by Spencer-Jones *et al.* (1975). The Shoreham, Coles' Beach, Point Leo area is dominated by the Thorpdale Volcanics of Eocene age which are locally overlain by veneers of Tertiary sands, sandy clays and silts. Shore platforms may be variably covered by calcareous dune and beach sand.

Grey to yellow podzolic soils are formed on Tertiary sediments, whereas brown podzolic and brown earth soils have developed from basalts. The degree of leaching and texture differentiation in the profile is dependent on topography and proximity to the sea.

METHODS

At Coles' Beach, three transects were located at right angles to the shore line, on a 300 m sector of the coast. Transect I was established on a steep, exposed cliff; Transect II on the unstable bluff supporting *Cyathea*

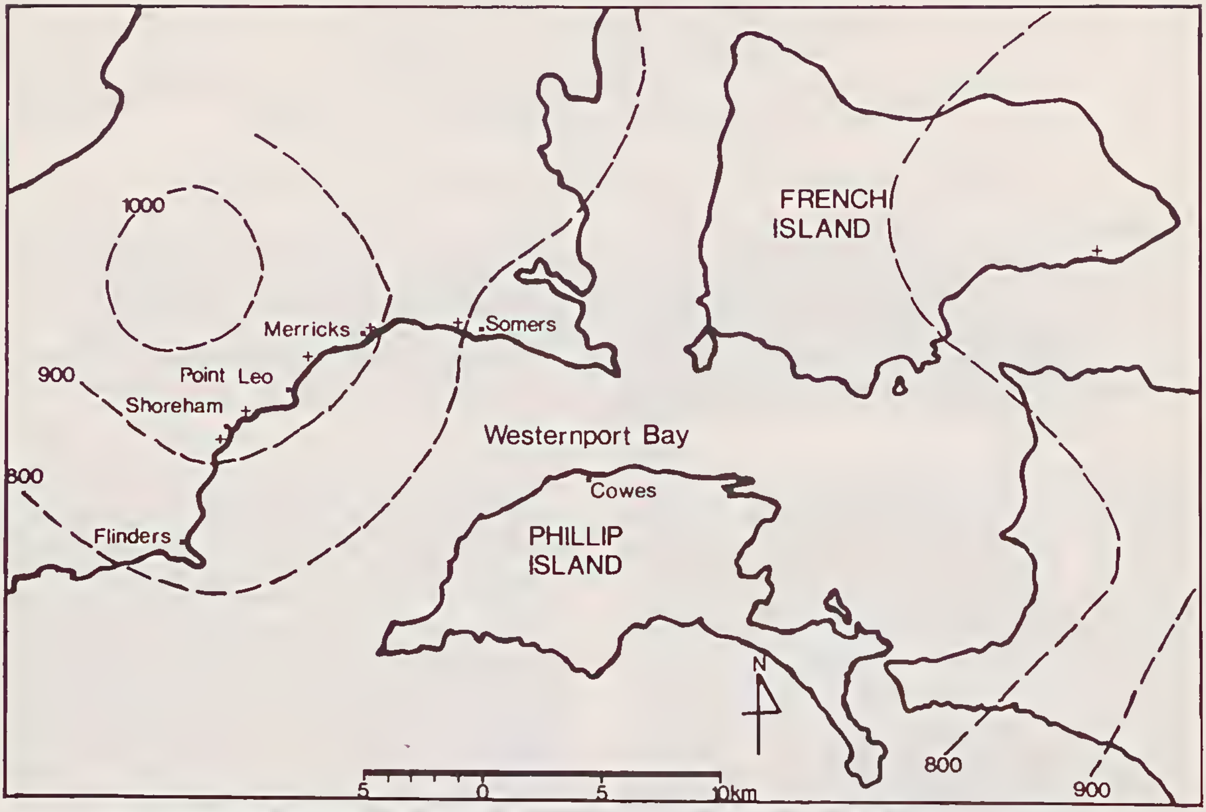

Fig. 1 — Map of Western Port showing tree fern localities (+) on the coast. Coles' Beach is between Merricks and Point Leo; the French Island occurrence is at Freeman's Point. Rainfall isohyets (mm) are shown by the dashed lines. Rainfall data from Shapiro (1975).

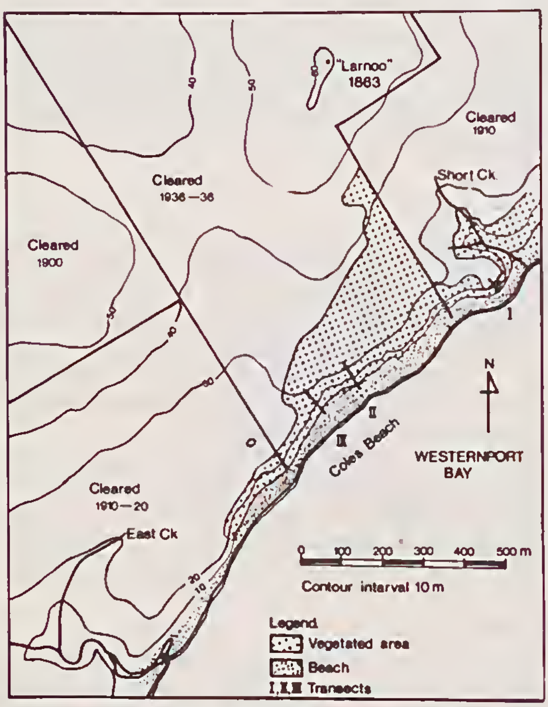

Fig. 2 — General map of the Coles' Beach area showing the land use of the hinterland since 1863.

australis; and Transect III on a stable bluff (Fig. 2). Along each transect, 4 × 1 m quadrats were established at 5 m intervals. In the tree fern community, a further 10 random quadrats were sampled. Within each quadrat, Braun-Blanquet cover values were recorded for each species. Soil holes were augered every 5 m, and soil texture and colour were recorded. Slope profiles at each site were surveyed with tape and clinometer or dumpy level.

TOPOGRAPHY OF THE COLES' BEACH SITE

This area, up-thrown by the nearby Tyabb Fault, slopes gently seaward, the rolling terrain terminating abruptly at a height of 8-10 m above mean high tide level. The coastal features are the product of marine attack and sub-aerial denudation from surface and subsurface water. Gravitational displacement is clearly important where internal resistance has been overcome by water lubrication.

On the more exposed headlands (e.g. Transect I), where sand sheets are absent, marine erosion has produced wide shore platforms and reefs (Hills 1976, Bird 1976). The bases of cliff slopes are subject to marine attack by high tides and storm waves. Due to the local resistance of less decomposed basalt, almost vertical cliffs are produced which suffer frequent rock-falls and slumps after heavy rains (Fig. 6). In this paper, 'cliffs' are defined as those slopes greater than 35° on which there is substantial exposure of underlying rock. The vegetal cover of such cliffs decreases dramatically with increase of slope (Fig. 7). 'Bluffs' are regarded as those vegetated slopes less than 35°, which rise sigmoidally from the beach. They may be further stabilized and degraded to gentler slopes by the combined action of soil creep and hill-wash (Bird 1977).

Stabilized bluffs are common between Merricks and Point Leo where they reach slopes of up to 21° (Fig. 8). At Coles' Beach there is little evidence of slumping at this relatively low angle of slope, and soil profiles at the base reflect a general mixture of wind-blown dune sand with clays, silts and loams washed down from above. The original beach at this point occurs at a depth of 100 cm, where sand is mixed with flat, waterworn basalt pebbles 2 to 15 cm in diameter.

Steeper bluffs of 30° to 33° are frequently unstable, and complex slumping is a conspicuous feature which has reduced the local slope angle to 10° to 20°. The major tree fern occurrences are associated with this diverse microtopography (Fig. 9). At Coles' Beach, judging from prolific seepage and 0.5 m deep cracks in sloppy clay, some areas are still moving. At many sites in this area, mixtures of subsoil, basalt fragments and topsoil have collected against the upper sides of tree trunks and logs to depths of 30 to 40 cm (Fig. 10). Headward erosion from some slumps has now reached the top-soils of the plateau edge, although others have ceased movement and the arcuate clifflets at their upper limits have grassed over.

Due to the rotational nature of the slumps (Selby 1970), back-walls (1 to 3 m high) of decomposed basalt have remained after the tongues of mud and debris have extended out over areas 20 to 30 m long and 5 to 10 m wide. The protected cirque-like basins which are so-formed, are wet and hummocky and some incipient drainage lines have been deflected by later flows. In some places muds have extended out over the dune for up to 4 m. The original slope surfaces, which are often reduced to narrow interfluves by lateral erosion from adjacent slumps, frequently display incipient instability by the presence of terracettes 1 to 10 m long and 10 to 30 cm high.

At the foot of the slope, erratic variations in clay and sand horizons indicate a fluctuating history of earth flows and dune encroachment. The original beach of pebbles and yellow sand occurs at a depth of about 1.3 m. The nature of the slump deposits can be seen in Fig. 4c where truncation has been affected by high tide erosion between Transects I and II.

Fig. 3—Victorian distribution of *Cyathea australis* per 10 minute grid. Shaded areas represent those regions receiving greater than 1000 mm annual rainfall. Much of the map was based on data provided by Mrs Betty Duncan, Monash University.

Fig. 4—Interior of a woodland of (a) *Cyathea australis—Acacia melanoxylon* and *Clematis aristata* at Coles' Beach. (b) A relatively large tree fern of *C. australis* 120 cm tall, on a grassy slope facing SE at Coles' Beach. This fern is often 'salt burnt' following on-shore winds from this quarter. *Eucalyptus viminalis* woodland is in the background. (c) Alternating top soil bands and clay rubble in an earth flow truncated by high tides at Coles' Beach north.

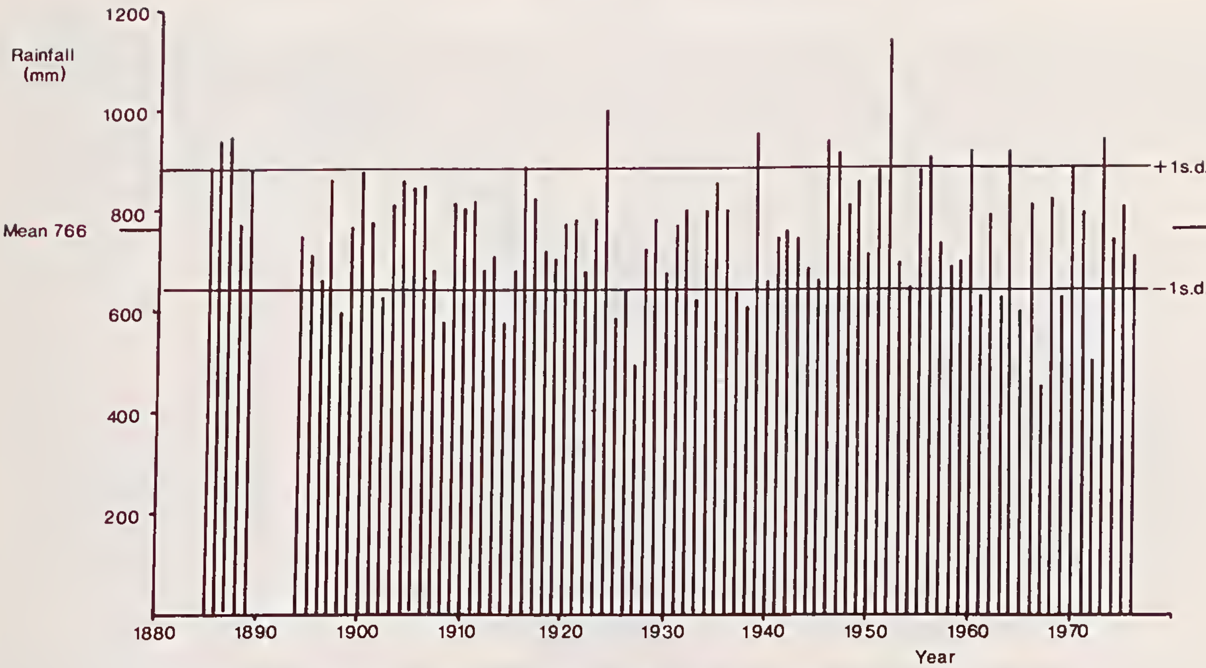

Fig. 5a—Variation of the annual rainfall at Cowes, Phillip Island, 10 km east of Coles' Beach.

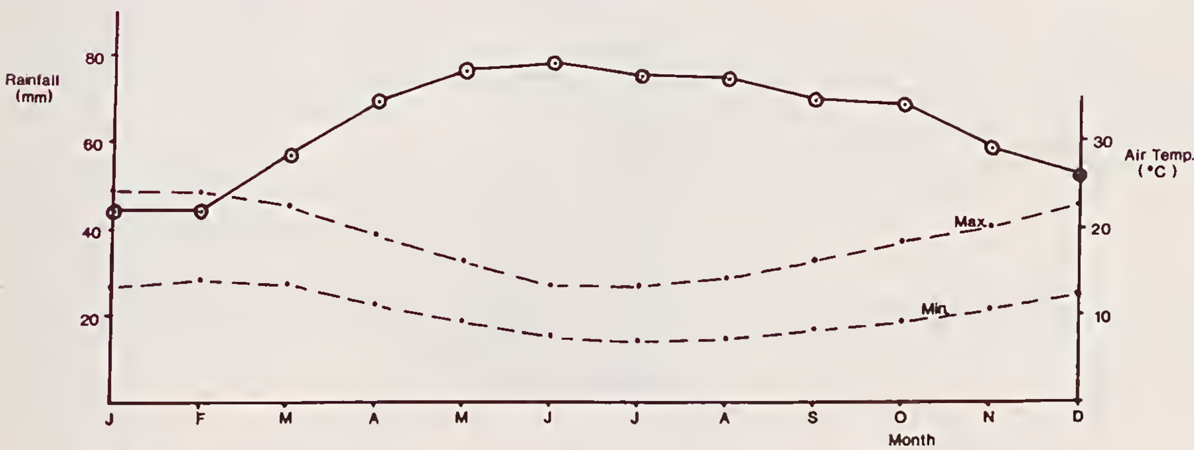

Fig. 5b—Seasonal distribution of rainfall (solid line) and air temperature (broken line) at Cowes. Cowes has the most complete set of rainfall statistics of any recording station near the study area. Annual rainfall figures for the years 1954-1957 were missing from the record. These figures were interpolated from a regression line correlating annual rainfall data from Cowes and Frankston over the period 1919-1975.

The occurrence of landslides in Victoria appears to be primarily controlled by the rock or soil type. The seasonal distribution of rainfall may be broadly related to landslide activity, but heavy rains are usually only a 'catalyst' (Evans & Joyce 1974). Another factor causing instability on the Coles' Beach bluffs is likely to be the behaviour of ground water, especially its depth fluctuations. A dumpy level survey of Short Creek indicated that the water table spring at its source was 21 m above high tide mark on 12/12/1979 at a distance of 210 m from the beach (Fig. 11). This intersection of the water table was about 2 m above the junction of the basalt flows and the Tertiary sands and silty clays. The creek was brackish near its source with a salinity of 5.1‰t.d.s.—a value only 1/7th of that of sea water. The water tables in the Coles' Beach bluffs are likely to be of shallow origin and intake recharge may be derived from areas such as the broad sand-capped hill, 60 m above sea level and 1 km inland, which was cleared for the original 'Larnoo' homestead in 1863. A very broad divide extends directly from this hill along a 2° slope to the small forested area on the 'hinterland plateau' above the unstable bluff site (Fig. 2). It seems probable that ground-water discharge occurs down this slope and is in-

TABLE 1

THE PERCENTAGE FREQUENCY OF SPECIES OCCURRENCE IN 10 RANDOM QUADRATS (1+4 m) IN THE UNUSUAL WOODLAND OF TREE FERN (*Cyathea australis*)—BLACKWOOD (*Acacia melanoxylon*) ON SLUMPED CLAYS ON THE COLES' BEACH SITE, 1978. Figures in brackets indicate the frequency where cover exceeds 5%.

LIFE FORM AND STRATA	SPECIES	FREQUENCY
Tree and shrub strata		
Trees	*Eucalyptus viminalis*	20
	Acacia melanoxylon	40 (30)
	Banksia integrifolia	20
Shrubs	*Helichrysum dendroideum*	10
	Bursaria spinosa	10
Tree fern	*Cyathea australis*	30 (20)
Lianes	*Clematis aristata*	80 (50)
Field and ground strata		
Ground ferns	*Pteridium esculentum*	90 (40)
	Adiantum aethiopicum	90 (10)
Graminoids	*Poa labillardieri*	100 (70)
	Lepidosperma laterale	40
	Holcus lanatus	30
	Microlaena stipoides	20
	Echinopogon ovatus	10
Dicotyledon forbs and scramblers	*Geranium potentilloides*	100
	Galium parisiense	70
	Acaena anserinifolia	40
	Senecia jacobaea	40
	Epilobium glabellum	30
	Rubus ulmifolius	20
	Stellaria pungens	20
	Sonchus asper	20
	Dichondra repens	20
	Lobelia alata	20
	Oxalis corniculata	10
	Glycine clandestina	10
	G. latrobeana	10
	Hypochoeris radicata	10
	Rubus parvifolius	10
	Cirsium vulgare	10
	Gnaphalium japonicum	10
Bryophytes	*Fissidens asplenifolius*	50
	Ptychomnion aciculare	10
	Sematophyllum amoenum	10
	Lophocolea semiteres	10

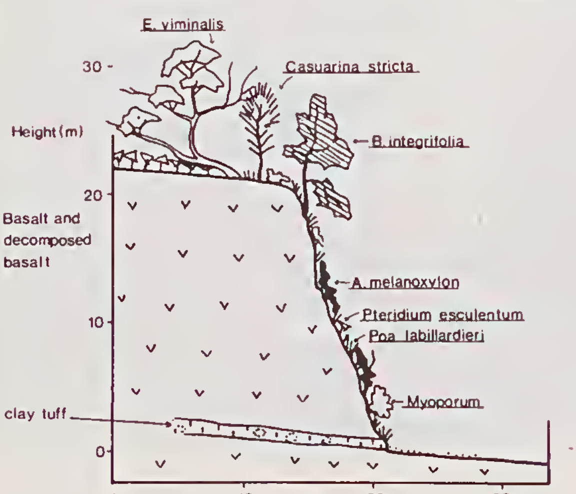

Fig. 6—Vegetation and land profile of the cliff and shore platform at Transect 1.

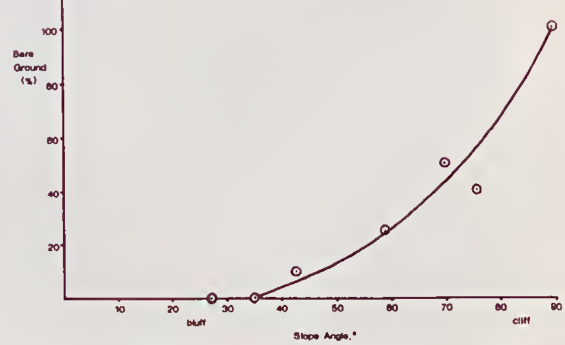

Fig. 7—The relationship between the amount of bare ground and the angle of slope in the Coles' Beach area. Bare ground cover was subjectively assessed and the curvilinear relationship estimated by eye.

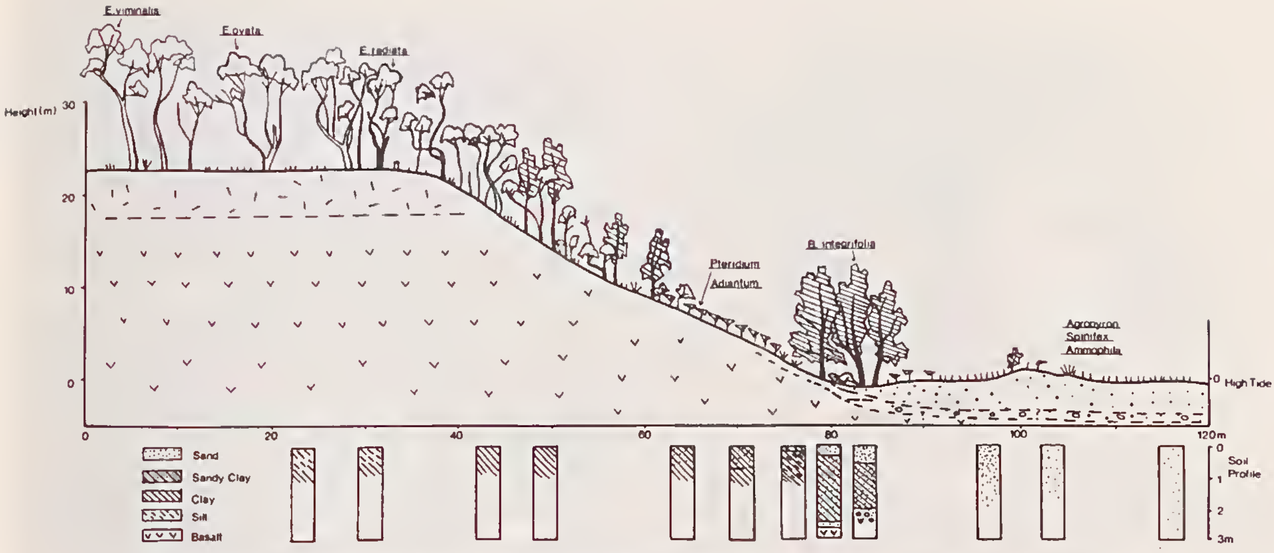

Fig. 8—Vegetation and land profiles of the stable bluff along Transect III, Coles' Beach. B = *Banksia*; E = *Eucalyptus*.

tersected by the slumping bluff surface about 20 m above high tide approximately at the junction of the decomposed basalt and the Tertiary sediments. The relative stability of the bluffs to the north and south of the central area may be preserved by a deflection of ground water discharge along the lateral drainage lines which run parallel to the coast along slopes of 3 to 5° in this area.

Sodium predominance in the clay complexes in this maritime site is certain to render the soils more fluid and dispersable in wet conditions (Leeper 1957). The soils of the basalt areas are brown, friable loams over red/yellow mottled sticky clays, whilst those on the Tertiary deposits are grey fine sandy loams over heavy yellow clay. In both soil types the presence of magnetic buckshot gravel in the lower A horizons suggests periodic waterlogging—a prerequisite of mass soil movement.

It is well known that clearing of eucalypt forest for pasture development can result in reduced water use and a rise in the level of the water table. It seems highly likely therefore that this has been the case in the Coles' Beach area following general clearing from 1910 to 1938. A greater flow of ground water would not only increase the likelihood of slumping but also tend to cause instability higher up the slope of the bluff.

VEGETATION AT THE COLES' BEACH SITE

At this site the largely intact vegetation appears as a moderately low open-forest or woodland which descends from an almost level plateau to a set of 2 or 3

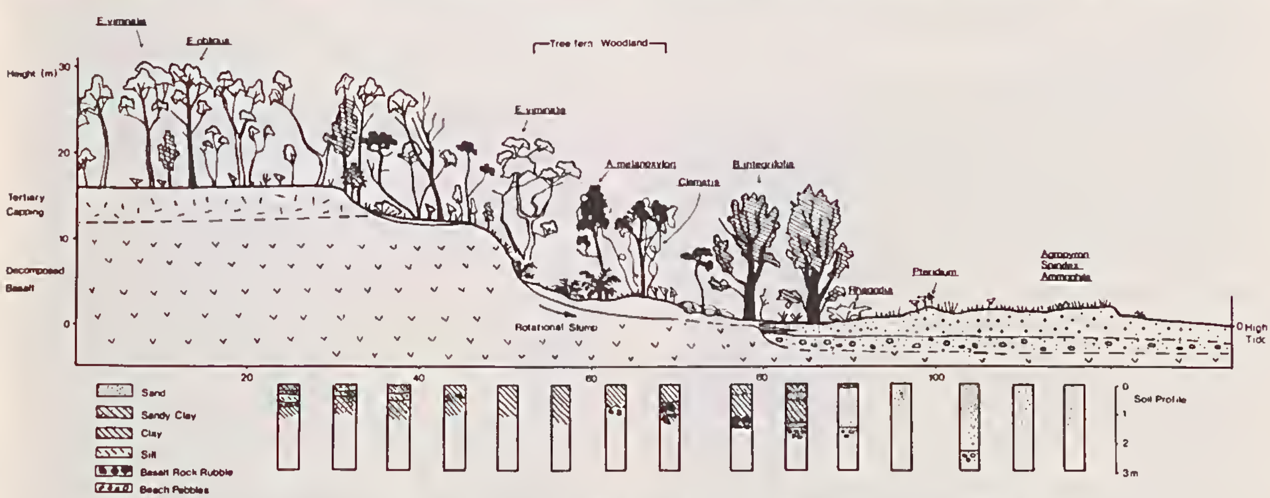

Fig. 9—Vegetation and land profiles of the unstable bluff along Transect II, Coles' Beach. B = *Banksia*; E = *Eucalyptus*; A = *Acacia*.

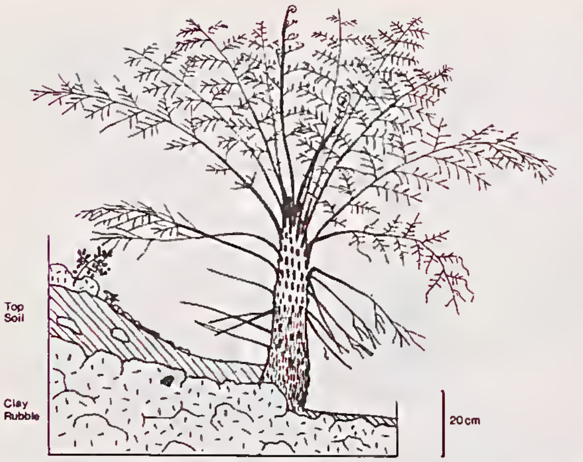

Fig. 10—Build-up of hill wash against a young tree fern (12 to 13 years old), on the lower slopes of an earth flow, Coles' Beach. The rate of accumulation against the 6 year old trunk could be about 1 cm per year.

grassy dunes 1 to 2 m high and 30 to 40 m broad. It is likely that these deposits with scattered, resistant *Banksia* have protected some of the bluff vegetation from the worst excesses of salt spray. The vegetation has been mapped on a structural basis, and for convenience named according to the dominant plant form. A purely floristic analysis may have grouped the communities differently but it is not likely to have modified the conclusions. The major communities described below are closely correlated with local topography and soil as shown in maps (Figs 12, 13) and profiles (Figs 6, 8, 9). Ground vegetation is often most luxuriant at the dune/slope junction where moisture supplies are reliable but not excessive. The tallest trees usually occur on the mid to lower slopes in response to less exposure and better moisture status. An analogous situation occurs on French Island near Freeman's Point, where a narrow zone of wet sclerophyll shrubs (*Olearia argophylla, Rapanea howittiana*) appear beneath taller *E. obliqua* trees.

The communities are:

1. Sand Dune Complex consisting of:

(a) Foredune grassland of *Spinifex hirsutus, Agropyron junceum, Ammophila arenaria* and *Cakile maritima.*

(b) Hind dune complex of graminoids (*Scirpus nodosus, Lagurus ovatus, Stipa compactus*) together with *Acaena anserinifolia* and scattered bracken. Small bushes of *Banksia integrifolia* are establishing in areas of this zone, either by seed or by root suckers. This situation appears to be successional and is a similar pattern to previous descriptions (Bird 1976).

2. Fernland of bracken —(*Pteridium exculentum*) at the base of the main slope. This is often tangled with *Clematis aristata*, associated with or without an understorey of maidenhair fern (*Adiantum aethiopicum*). In many sites, vigorous patches of blackberry (*Rubus ulmifolia*) have overcome the bracken stands.

3. Woodland of *Banksia integrifolia* on two types of site; on the sands and mixed clay soils at the bluff/dune junction and on the hind dune associated with dune plants such as *Rhagodia baccata* . On some of the basalt slopes, especially the lower slopes, it is associated with an understorey of tussock grass (*Poa labilliardieri*) and various forbs. It seems that these latter sites are similar to those occupied by eucalypts. Some *Banksia* communities bear evidence of old eucalypt stumps and fallen trees. Possibly, the eucalypt component requires fire for adequate perpetuation whereas *Banksia integrifolia* may continue to regenerate vegetatively.

4. Woodland of *Acacia melanoxylon* in association with *Cyathea australis* and *Clematis aristata* on slumped sites. This community has a low, scattered tree canopy but the ferny, herbaceous stratum—consisting of *Adiantum aethiopicum, Pteridium esculentum, Poa labillardieri, Geranium potentilloides* and *Galium parisiense*—is luxuriant (Fig. 4a). Areas of damp clay-rubble associated with the tree ferns are almost invariably colonized by the moss, *Fissidens asplenifolius.* The percentage frequency of species in this community is illustrated in Table 1.

5. Open Forest of *Eucalyptus viminalis—E. obliqua* on the slopes. This is a predominantly grassy community with an understorey of *Poa labillardieri* and forbs. On the gentler slopes *E. radiata* and *E. ovata* also occur. *Banksia integrifolia* is a common understorey or

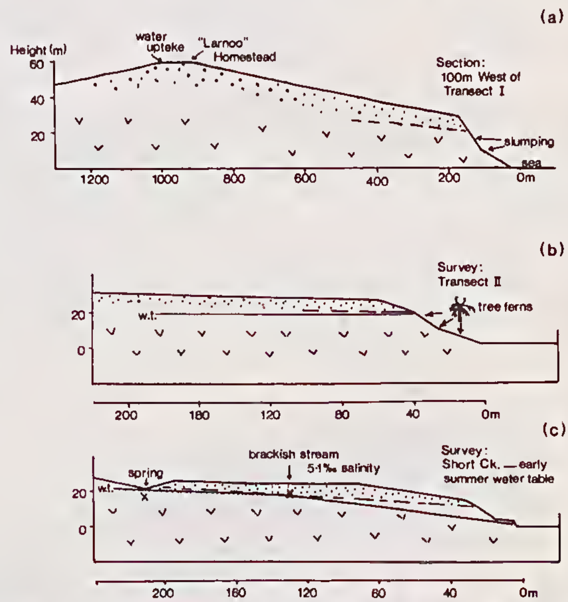

Fig. 11—Land profiles in the Coles' Beach area in relation to Tertiary sand and sandy clay cappings (stippled), the limit of which is shown by a dashed line. The depth of the ground water table along Short Creek was determined by survey offsets from the transect lines.

a. Section 100 m west of Transect I. (Source: Contour Map, 10,000/4, 6, 1973). Vertical exaggeration × 5.

b. Survey of Transect II.

c. Survey of Short Creek.

Slumping areas occurred on the bluff slopes of each of the three transects. The extensive slumping on (b) is associated with a definite perched water table.

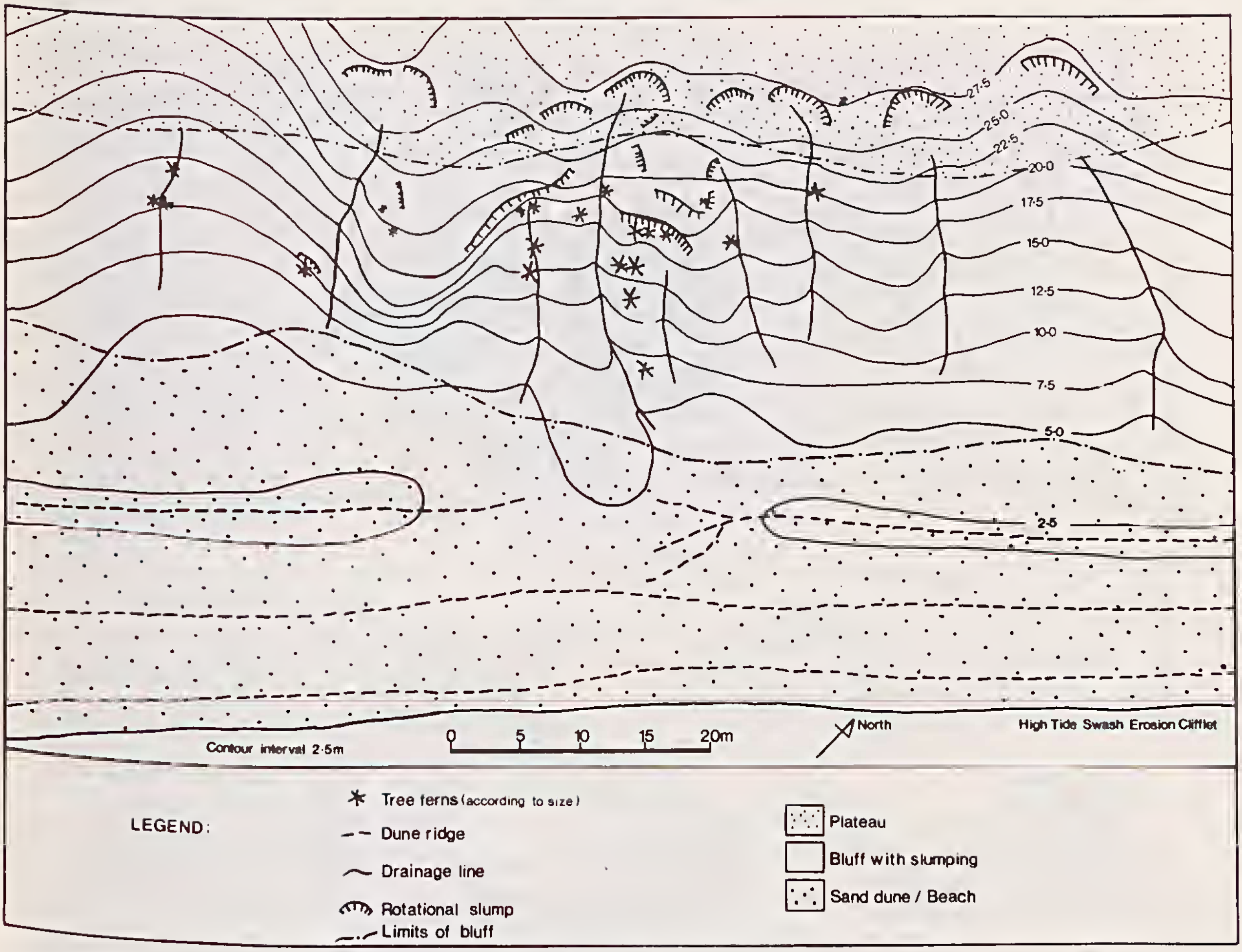

Fig. 12—Landform map of the Coles' Beach site showing the distribution of tree ferns.

codominant species and is associated with *Helichrysum dendroideum* and *Bursaria spinosa*. Large-crowned *C. australis* sometimes occur on terraced grassy slopes in this community and are visible from the beach (Fig. 4b). Establishment of *Pittosporum undulatum* into these slope communities is very common, as it is over much of Mornington Peninsula, where both seed sources and bird vectors are present. The mature development of this species will undoubtedly greatly modify these communities—as will the invasion of blackberry thickets.

6. Low Grassy Woodland complex of shrubs and scattered low trees of *Casuarina stricta* and *Banksia integrifolia*. In addition, the highly disturbed cliffed site, to the north of the main study area, also supports stunted, prostrate *Acacia melanoxylon*, scattered bushes of *Rhagodia baccata* and tussocks of both *Lomandra longifolia* and *Poa labillardieri*.

7. Mixed Plateau Open-forest of *E. obliqua, E. radiata, E. viminalis* and *E. ovata*. The frequencies of these species change locally, probably in response to seasonal waterlogging conditions. These dominants are associated with *Danthonia racemosa, Poa sieberiana, Xanthorrhoea minor* and *Leptospermum juniperinum*. The understorey has been modified to some extent by cattle grazing.

STATUS OF DEVELOPMENT OF *Cyathea australis*

The majority of tree ferns on the west coast of Western Port have trunk heights less than 1.5 m and crown diameters of about 4 m. However, at Shoreham and Somers, occasional large specimens reach heights of 2.9 and 3.2 m respectively. The frequency histograms of tree fern heights at Coles' Beach, Shoreham and Somers are compared in Fig. 14. It is clear that the Shoreham stand is bimodally distributed whilst that at Coles' Beach has only one major peak of trunk heights. The coincidence of population frequency peaks at the two sites may mean that establishment has been synchronised by similar events. The reduced frequency peaks of taller classes at Shoreham (and to some extent, Somers), suggest that there have been additional earlier phases of establishment.

Cyathea australis at Coles' Beach is actively regenerating, since 41% of plants are sessile, with crown 0.3 to 3.0 m in diameter. Young plants are found where

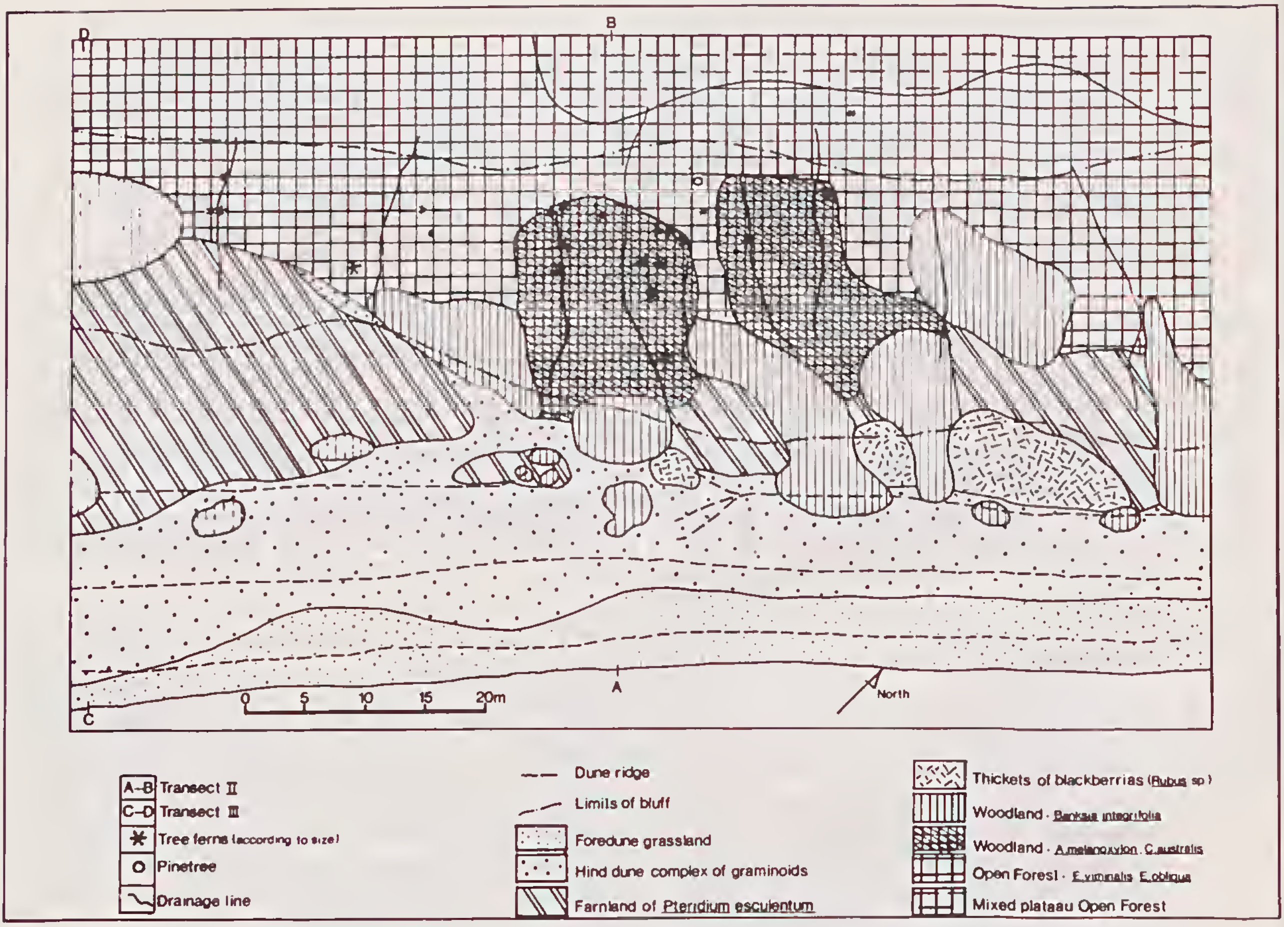

Fig. 13—Map of the main structural vegetation units at Coles' Beach.

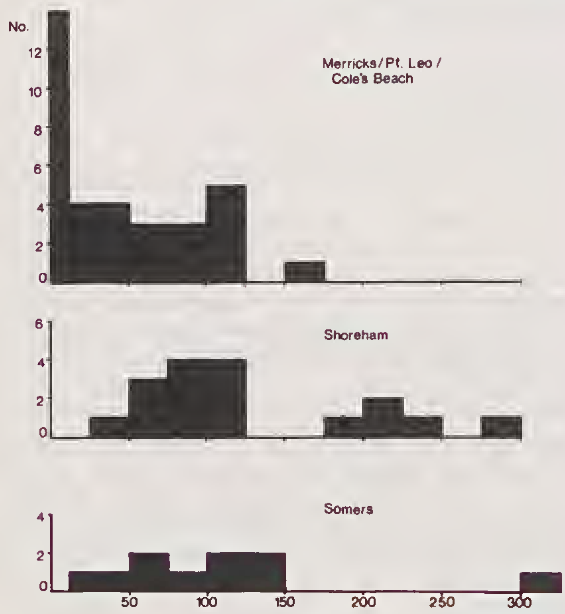

Fig. 14—Frequency histogram of tree fern heights at the three major tree fern localities—Shoreham, Coles' Beach and Somers.

the ground stratum of bracken, maidenhair fern, grasses, forbs and *Clematis* vines is incomplete. At Shoreham, regeneration is absent beneath dense blackberries—the few small plants occurring only where this weed is still sparse. At Somers, the situation is similar, and regeneration occurs only where the dense wreaths of the introduced *Asparagus asparagoides* are patchy. It is expected that regeneration of the tree fern at Coles' Beach will eventually be curtailed by blackberry growth. However, the regeneration of the tree fern on moist clay surfaces is rapid, since at Shoreham, fernlings appeared in late 1978—within six months of a track being graded through a tree fern site that had been cleared of dense blackberries.

From general ecological observations, the mature tree fern appears to be intolerant of prolonged drought and excessive insolation. The development and survival of the prothallus is likely to be dependent on the maintenance of moist and locally humid microclimates. These conditions are frequently satisfied by moist clay soil on slopes where obliterating litter cannot accumulate. At Coles' Beach, 50% of all tree ferns occur in seepage areas or erosion furrows in and between clay slumps; the remainder occur on open slopes where bare soil has been exposed by terracettes, hillwash or wombat

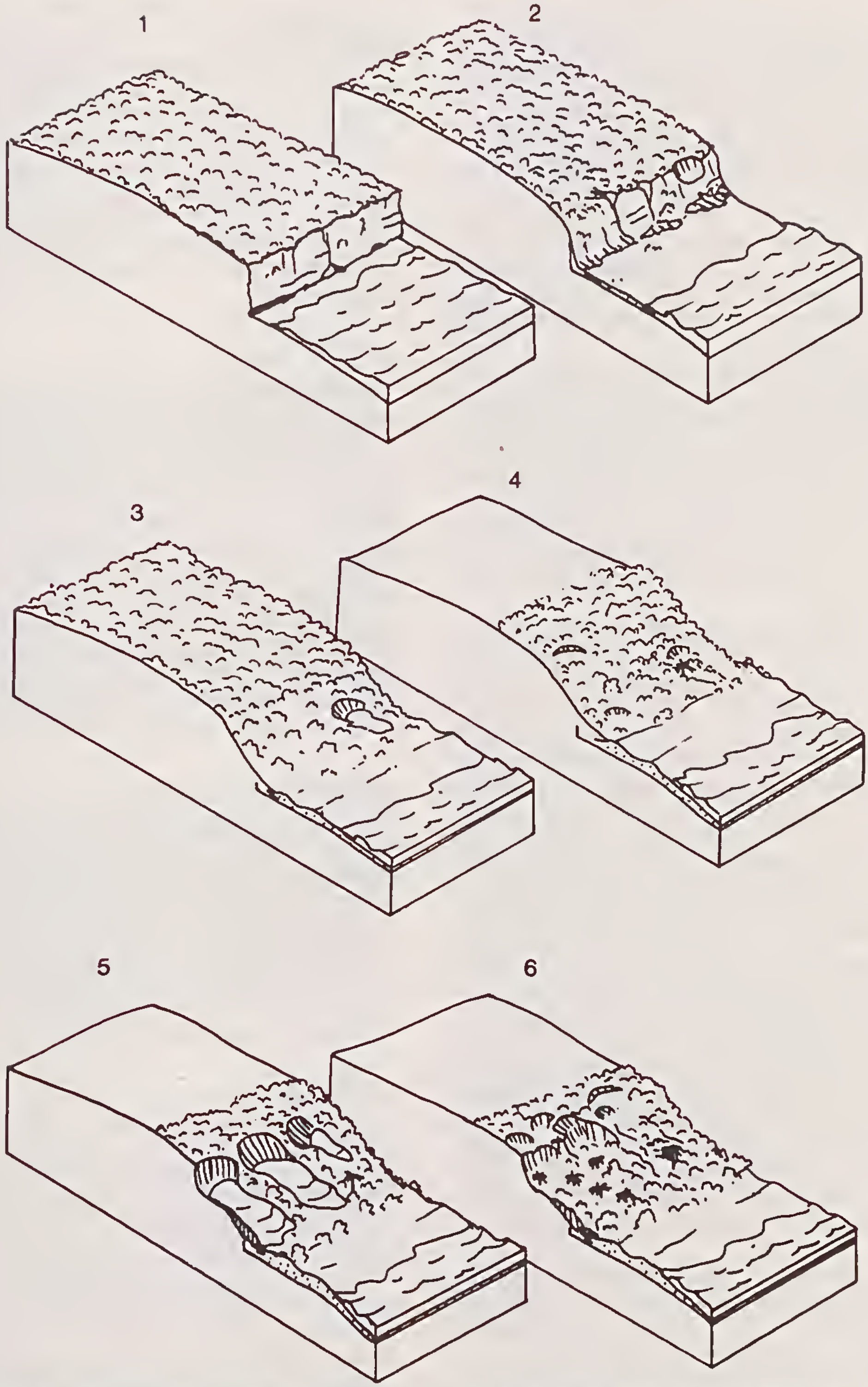

FIG. 15 — Block diagrams depicting the possible sequence of development of the tree fern habitat at Coles' Beach:

1. Cliff kept active by marine erosion.
2-3. With the build up of protective dunes, sub-areal processes denude cliffs to bluffs.
4. Hinterland cleared of forest causing a rise in water table levels.
5-6. Slumping activity increases, creating suitably moist habitats for the establishment and survival of *Cyathea australis*.

burrowing. A few in the latter sites have succumbed to drought. The ages of slumps providing conditions for tree fern establishment are not generally known. Since the biology of this species is incompletely known, the age structure of the stands can only be surmised.

Examination of five of the larger tree ferns at the Coles' Beach site in November 1979 revealed that an average of 14 fronds had been produced in the current spring season. The number of older, green and decadent fronds average 17. The length of stem subtending the older fronds averaged 11 cm. If allowance is made for a few fronds being older than one year, the annual stem growth could be about 10 cm, or the equivalent of two spirals of frond insertions.

Some corroboration of these results was obtained by measuring the growth of tree ferns beyond the char-line of the 1968 fires in Ferntree Gully National Park. The average increment of six trunks of *C. australis*, 2.5 to 4.9 m tall, was 11.3 cm per year. Thus for enriched post-fire conditions in a wet sclerophyll environment at an altitude of 200 m the annual growth rate was 10.5 cm. On the basis of these estimates the minimum age of the trunks of the Coles' Beach ferns may be only 5 to 13 years.

The period from spore germination to trunk development is more difficult to estimate. Observations are limited to the development of a transplanted rosette of *C. australis* 30 cm in diameter, in a Surrey Hills garden (Melbourne) over 20 years. A trunk, 33 cm high, developed after seven years and an extrapolation of subsequent height growth measurements (5.5 cm/yr. to zero) indicated that the juvenile rosette period was likely to be about four years. A similar time to develop to the rosette stage seems reasonable in view of glasshouse observations of prothallial and fernling stages. The age of the larger, mature tree ferns at Coles' Beach could therefore be between 12 and 20 years old. The largest specimen at Shoreham may be 35 to 40 years old, whilst that at Somers may be at least 50 to 55 years old, since growth rate is likely to diminish with increasing age.

Tree ferns may have arrived on the coastal bluffs by chance spore dispersal from the fern gullies of the Red Hill district, 10 to 15 km up-wind to the west and north west of this coastline. At the Shoreham bluffs, they are known to have been present for the last 62 years (1918-1980) (M. Wainwright pers. comm., 1980), although on the lower, weedy stretches of nearby permanent creeks (Stony Ck. and East Ck.) they appear to be absent.

At the French Island site, a cliff slump was estimated to have occurred 14 years ago, judging from the maximum number of whorls of branches on vigorously invading *Pinus pinaster* saplings. The oldest tree fern on this slump is 50 cm high and is estimated to be 9 years old. It is growing in a moist habitat, and although saltburnt, is protected locally from the prevailing SW winds by a projecting clifflet. It would appear that *Cyathea australis* is readily able to colonise such habitats when they become available, although at the French Island site, the persistence of the ferns is in jeopardy due to impending marine erosion of both the slump and the projecting clifflet.

The impression gained from this initial study is that the colonization of tree ferns on most bluff sites has been a relatively recent phenomenon. The steles of tree ferns are resistant to decay for many years. No remanants of large ferns have been found. The mature tree fern is resistant to all but the most intense fires (Jarrett & Petrie 1929). Since none of the tree ferns at Coles' Beach show evidence of charring on their lower trunks, they are certainly younger than the last fire in 1941 (Lorraine Coles pers. comm.).

CONCLUSIONS

An hypothesis which may account for the habitat complex and the general youth of the tree fern population at the Coles' Beach site concerns the rise of water table following general land clearance on the gentle hinterland slopes. If this has happened, then clays of the mid-slopes of the vegetated bluff, which may have been saturated by ground water only in very exceptional decades or centuries, have now been much more frequently under its influence. Instability may have been triggered by flood rains, such as occurred in 1952 and 1956, and have continued with variable activity until the present day. A summary of the possible generalised sequence of development of the unusual tree fern habit on the west coast of Western Port is shown in Fig. 15.

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REFERENCES

Bird, E. C. F., 1976. *Coasts*. 2nd Edition. A.N.U. Press, Canberra.

Bird, E. C. F., 1977. Cliffs and bluffs and the Victorian coast. *Victorian Nat.* 94: 4-9.

Bird, E. C. F., 1979. Victorian coastal geomorphology. *Proc. R. Soc. Vict.* 92: 19-35.

Evans, R. S. & Joyce, E. B.,1974. Landslides in Victoria, Australia. *Victorian Nat.* 91: 240-245.

Hills, E. S., 1976. *Physiography of Victoria.* Whitcombe & Tombs, London.

Jarrett, E. S. & Petrie, A. H. K., 1929. The vegetation of the Blacks' Spur Region. A study in the ecology of some Australian mountain *Eucalyptus* forests. II. Pyric succession. *J. Ecol.* 17: 249-281.

Leeper, G. W., 1957. *Introduction to soil science.* 3rd Edition. Melbourne University Press, Melbourne.

Selby, M. J., 1970. *Slopes and slope processes.* Waikato Branch of the New Zealand Geographical Society (Inc.) Publication No. 1. 59 pp.

Shapiro, M. A., 1975. *Westernport Bay Environmental Study* 1973/74. Ministry for Conservation, Victoria.

Spencer-Jones, D., Marsden, M. A. H., Barton, G. M. & Carrillo-Rivera, J. J., 1975. Geology of the Westernport Sunkland. *Proc. R. Soc. Vict.*, 87: 43-68.